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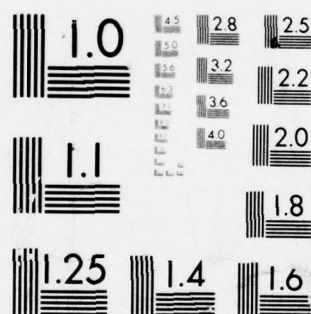


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EUROPEAN SCIENTIFIC NOTES

15 September 1951

Vol. 5, No. 13

IMPROVED INFRA-RED SPECTROMETER

Dr. Peter Fellgett (Cambridge) has suggested that it may be possible to increase the signal-to-noise ratio in infra-red spectroscopy by measuring the Fourier transform of the spectrum rather than the spectrum itself. The crux of his idea is that all of the wavelengths would be examined simultaneously throughout the recording, instead of being received one at a time as is the present practice.

The principle of the system may be understood by conceiving of a conventional spectrometer in whose exit focal plane a complex chopper is placed which modulates every different wavelength at a different frequency. If all of the wavelengths are then focused on to the same receiver, a complex waveform is produced from which the spectrum might be deduced.

Fellgett's suggestion is that the experiment may be simplified by modulating the different wavelengths with an interferometer. No dispersing system is needed and as the interferometer spacing is changed, every wavelength is automatically modulated at a frequency proportional to its own frequency (or wave-number). The frequency spectrum of the waveform thus produced is then a copy of the spectrum of the radiation itself.

The system may be compared with the Michelson method of observing the visibility of the interferometer fringes of a spectral line to deduce its fine-structure. It differs by preserving the phase of the fringes, and thus can be successfully applied in the general case.

In his doctoral thesis at Cambridge, Dr. Fellgett has demonstrated mathematically that the interferometer method can be expected to yield as good a resolving power as conventional techniques at an improvement in signal-to-noise ratio that may be as great as \sqrt{N} where N is the number of elements into which the spectrum may be resolved. In simple experiments using interference between plane-parallel unsilvered glass plates, he has been able to deduce the spectrum of a tungsten filament and a Hg lamp, and to verify the expectation of improving the signal-to-noise ratio.

In these experiments the radiation intensity was recorded and plotted as a function of interferometer spacing. The resulting interferogram was then analysed into its periodic components by the method of Lipsom-Beevers strips to yield the Fourier transform, i.e., the spectrum of the original source. It is Dr. Fellgett's opinion that the rapid and automatic reduction of the interferogram to yield the spectrum should be technically feasible without appreciably influencing the signal-to-noise ratio or the time to determine the spectrum.

Dr. Fellgett is planning to spend this winter at the Lick Observatory.

FARADAY SOCIETY DISCUSSION ON THE SIZE AND SHAPE FACTOR IN COLLOIDAL SYSTEMS

The recent General Discussion of the Faraday Society at Leamington Spa (July 18-20, 1951) dealt with the size and shape factor in colloidal systems. The main subjects of discussion were size distribution and mechanical properties, nucleation phenomena, micelles, polyelectrolytes, cellulose, muscle, and viruses.

The complete Proceedings of the Discussion will be published by the Faraday Society in about six months. Technical Report ONRL-68-51, which summarizes some of the papers and discussions, will be available from the Technical Information Division, Code 250, Office of Naval Research, Washington 25, D. C.

Size and Size Distribution of Tobacco Mosaic Virus

Dr. Dervichian of l'Institut Pasteur, Paris, described experiments in which the size distribution of tobacco mosaic virus particles was measured. Six different juices were investigated. These came from plants of different ages which were inoculated with the virus at different times. The size of particles and polydispersion in the different original juices was very different. It was found, however, that treatment with sulfate increased the average particle size in all cases, while the addition of hydrogen chloride decreased it in all cases. Statistical evaluation of the results indicates that the size varies continuously, so that it is not possible to obtain discrete values which are integral multiples of a particular length, unless this elementary particle is smaller than 250A. This variation of size is found even in the original juices which have undergone no treatment at all. In agreement with William and Wyckoff, segmented appearance of the rods was observed suggesting that they may form by linear accumulation of nearly isometrical elements not exceeding a few hundred Angstroms.

Micelles

The present status regarding the structure of micelles was discussed by several authors. It appears that the conclusions reached by Debye from light scattering experiments and those of Philippoff from X-ray measurements are markedly different. Debye favors a cylindrical arrangement of rods while Philippoff's arrangement could be described as bimolecular leaflets. Dr. J. H. Schulman (Cambridge), in discussing the different models suggested, favored a lamellar or ribbon-like structure.

The general difficulty in micelle studies appears to be that each system investigated gives different possible structures. Evidence is available for the occurrence of many different forms--lamellar, cylindrical, rod-like and thread-like.

Size and Shape of Protein Molecules

E. P. Riley and G. Oster (Royal Institution, London) developed the necessary theory of X-ray and light scattering by colloidal and macromolecular systems enabling

them to reach conclusions regarding molecular size and shape in concentrated solutions. The method was applied to solutions of bovine serum albumin and human haemoglobin. Bovine serum albumin showed a two-dimensional hexagonal array of cylindrical molecules. The height of the cylinder corresponding to a molecular weight of 68,000 is 45A. The radius of gyration of such a cylinder is 25A, in reasonable agreement with previous X-ray scattering results.

The hypothesis that the human haemoglobin is nearly spherical in shape was confirmed. Assuming spherical molecules arranged with nearly crystallographic regularity, the diameter of the unhydrated molecule is 55A. In a saturated solution the intermolecular distance between centers is 62A. Such a solution contains enough water to form a monomolecular layer of hydration around each protein molecule.

Nucleation in Colloidal Sols

Two American contributions dealt with nucleation and growth phenomena. V. K. LaMer (Columbia) discussed sulfur sols, while J. Turkevich (Princeton) presented a new theory for the formation of a nucleus in gold solutions. It is postulated that the nucleating agent gradually builds up a complex between the gold ions, thereby chemically combining a large number of both gold ions and reducing agent molecules into large macromolecules. At some stage these undergo a molecular rearrangement to produce a metallic gold particle of sufficiently large size. This hypothesis finds support in the nature of the reducing agents capable of causing nucleation, and it also explains the marked temperature dependence of the rate of nucleation.

The growth of the particles was also studied in detail and led to a technique for the preparation of monodisperse colloids of various particle sizes. This is based on the fact that a slightly acid solution of chlorauric acid and hydroxylamine hydrochloride in a scrupulously clean closed vessel does not produce colloidal gold until nuclei are introduced. The metallic gold is deposited only on the nuclei introduced so that they increase in size but not in number. This technique to produce monodisperse metallic colloids which has been extended to platinum, palladium, and other noble metals should find numerous applications in catalytic research.

ISOTOPES TECHNIQUES CONFERENCE (CHEMISTRY)

On July 16-20 an isotopes techniques conference, organized by the Atomic Energy Research Establishment, was held at Oxford. The papers were contributed largely by the various groups who have used radioactive isotopes purchased from the AERE. Two papers of interest to chemists are discussed below.

Diffusion of Lead in Lead Silicates

Dr. R. Lindner (Göteborg) reviewed the radioactive tracer methods for the study of solid state reactions. Volume diffusion and interface diffusion can be distinguished by analyzing the distribution of the radioactive tracer found in successive cuts of thin layers of the material under investigation.

The diffusion of lead in lead silicates was measured using the α -absorption method and the contact method. The energy of activation of the diffusion of lead was found to be 47 Kcal/mole in lead orthosilicate, $2\text{PbO} \cdot \text{SiO}_2$, and 59 Kcal/mole in lead metasilicate, $\text{PbO} \cdot \text{SiO}_2$ (cf. ESN 4, 177 (1950)).

Electrochemical transference experiments in molten electrolytes are also being carried out using radioactive tracers.

Analysis of Free Radical Mixtures with Radioactive Tracers

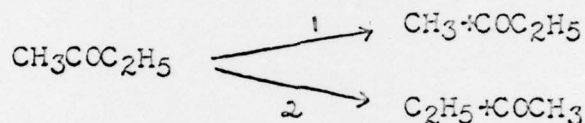
Dr. R. G. Martin (Durham) uses a radioactive tracer technique for the analysis of free radical mixtures. The method was applied to study the pyrolysis of the normal propyl radical and the photolysis of acetone and other ketones.

Short-lived aliphatic free-radicals can be "fixed" by reaction with elementary iodine. If this iodine is labelled with I^{131} , activity measurements performed on the products yield detailed information of the amounts of the different alkyl radicals formed. If the specific activity of the original iodine is known, absolute measurements of radical yields are also possible.

The pyrolysis of normal propyl radical to yield ethylene and methyl radical at temperatures of the order of

200-300°C gives a value of 32 ± 1 Kcal/mole for the activation energy of this bond rupture. The propyl radicals were produced by means of a Polanyi sodium-flame reaction between sodium vapor and propyl bromide. The sodium vapor acts as the carrier gas for the free radicals. The homogeneous gas phase nature of this reaction is shown by the fact that the same results are obtained in a packed tube or upon the addition of additional hydrogen, nitrogen, or argon carrier gas.

The primary act in the photolysis of acetone and methyl-ethyl ketone by ultraviolet light at room temperature is the formation of an alkyl radical and an acyl radical. The two alternative processes in the mixed ketone



were quantitatively compared and the preponderance of reaction 1 over reaction 2 was found to be 20:1 at $\lambda = 3100\text{\AA}$ and 2.6:1 at $\lambda = 2000\text{\AA}$.

KIRKENDALL EFFECT

Studies of the Kirkendall effect in diffusion are being made at the Atomic Energy Research Establishment at Harwell, Berks., by R. S. Barnes of the Metallurgy Division. The original Kirkendall experiment has been repeated and additional experiments devised, particularly in the copper-nickel system which was chosen because of its complete solubility range.

To magnify the change in thickness of the diffusion zone, a sandwich of some 50 alternate sheets of copper and nickel was made by hot rolling. At intervals during the diffusion annealing treatment, measurements were made of the total thickness with a micrometer, and this thickness was found to increase with the square root of the time. Metallographic examination of the cross-section of the sandwich showed holes on the copper side of each diffusion zone, due to the coalescence of lattice vacancies diffusing preferentially into the copper. If the specimen is electrolytically polished, these holes appear merely as round pits but, if the specimen is given a careful mechanical polish, these

holes appear in their true shape; they have a rather small number of flat sides meeting at sharp corners and might be termed "negative crystals".

These experiments also show that a considerable amount of strain exists near the diffusion zone. If a cross-section of the specimen is polished flat before the diffusion anneal, metallographic inspection after the anneal shows that the material on the copper side of the diffusion zone has been pushed up at the surface to form a series of waves or ripples. A back-reflection Laue photograph of this same region with a 60 micron X-ray beam shows a considerable amount of polygonization, the fragments being disoriented by as much as 6 degrees. (This sort of X-ray work is made possible by a specially constructed camera which allows one to locate an X-ray beam on the specimen within about 10 microns of a point previously selected under the microscope.)

An incidental result of these experiments at Harwell was the demonstration that the grain boundary diffusion rate of copper in nickel was greater than the lattice diffusion rate. This latter work is described in Nature 166, 1032 (1950).

INTERNAL OXIDATION OF ALLOYS

The properties of internally oxidized alloys are being investigated at the Metallurgy Laboratory of Cambridge University, under the direction of Prof. W. G. Austin. Most of the present work is devoted to an examination of the mechanical properties of these materials.

The alloys used are usually silver-base, containing either 0.05 or 0.25 percent of silicon or aluminum by weight. The chief difference between the Al-bearing and Si-bearing alloys is in the particle size of the oxide after internal oxidation. The alumina particles are always smaller than the silica particles and this difference is reflected in the greater strength and lower ductility of the Al-bearing alloys. The effect of oxide particle size is also apparent in experiments where the oxidizing temperature is varied--the lower the oxidizing temperature, the smaller the oxide particles and the stronger and more brittle the alloy.

Internally oxidized alloys are always found to be stronger and more brittle than unoxidized alloys. If an oxidized alloy is heated to a temperature higher than that at which it was oxidized, usually 650°C, coarsening of the oxide particles takes place and the strength decreases but it is still stronger than an unoxidized specimen. Incidentally, these experiments are not complicated by grain size variations since the oxide particles are very effective in inhibiting grain growth.

All the above remarks refer to room temperature tensile properties. When tested at elevated temperatures up to 600°C, both oxidized and unoxidized alloys naturally decrease in strength but the oxidized alloys lose less of their room temperature strength than the unoxidized ones.

Oxide particle sizes have been studied by extraction of the oxide and examination with an electron microscope, which shows that both the silica and the alumina particles are spherical, with sizes ranging up to about 1000A. Sizes are measured on the electron micrograph and size distribution curves prepared. These curves show that increased oxidizing temperatures do not increase the maximum size, which remains at about 200A, but they do increase the relative number of particles in the larger size ranges. From each size distribution curve, a value for the mean spacing between particles can be derived and it is found that the yield strength of an oxidized alloy is inversely proportional to this mean spacing, in agreement with theories advanced by Bragg and by Crowan.

Fractures in internally oxidized alloys tend to be intragranular rather than transgranular, probably due to a tendency for the oxide particles to segregate slightly at grain boundaries. This view is supported by the fact that both oxidized and unoxidized alloy single crystals have more or less the same ductility although the former are stronger. Also, if an alloy single crystal is oxidized and then cold worked and recrystallized, it is more ductile than an oxidized polycrystalline specimen of the same alloy, since in the former case the grain boundaries were created after the oxidation and grain boundary segregation had no chance to occur.

Fatigue tests are now being carried out on internally oxidized Cu-Si alloys in order to study the effect of oxide particles on crack propagation. The oxidized alloys are found to have a lower fatigue strength than the unoxidized ones. Whether this is due to grain boundary segregation or to the effect of the oxide particles themselves will be decided by making fatigue tests on oxidized single crystal specimens.

THE RELATION BETWEEN TENSILE PROPERTIES AND RECRYSTALLIZATION

At the Centre de Recherches, Ecole des Mines, Paris, B. Jacul and Prof. C. Crussard, Director of the laboratory, are investigating the shapes of stress-strain curves in relation to recrystallization. They find that the stress-strain curves of zinc, copper, magnesium, aluminum, and aluminum alloys can be expressed by two equations of the form:

$$S = S_0 + A E^m$$

$$S = S_0' + A E^n$$

where S and E are the stress and strain respectively and the other quantities are constant. The first part of the stress-strain curve is represented by the first equation and the second part by the second equation. Particular significance is attached to the strain E_p separating these two parts of the curve (cf. ESN 4, 217 (1950)).

For example, if the strain is less than E_p , the spots on an X-ray diffraction pattern show asterism which no amount of annealing can remove, but if the strain exceeds E_p , low temperature annealing removes the asterism and the spots become broken up in a way characteristic of polygonized metal. The strain E_p , in fact, is found to be equal to the critical strain required for recrystallization. Below E_p no recrystallization occurs, at E_p the specimen may be converted into a single crystal and above E_p the recrystallized grain size decreases as the strain increases.

A distinct yield point was found in an alloy of aluminum and 3 percent magnesium. In this case, Jacul and Crussard identify E_p with the end of the yield phenomenon, where the stress begins to rise again continually. Defined in this way, E_p again corresponds to the critical strain required for recrystallization. Mild steel exhibits the same behavior; here the yielding continues to about 2.5 to 3.0 percent and the critical strain is 2.75 percent.

INTERACTIONS OF DISLOCATIONS AND SOLUTE ATOMS

Some time ago Prof. A. H. Cottrell of the Metallurgy Department of Birmingham University presented a theory of the yield point phenomenon which subsequently received considerable experimental verification. This theory postulated an interaction between dislocations and interstitial solute atoms such that the stress required initially to free a dislocation from a solute atom was larger than the stress required for subsequent movement of dislocations. Further work on the yield point phenomenon in the light of this theory is being carried out at Birmingham.

For example, it has been found that a single crystal of iron containing 0.02 percent carbon exhibits a yield point at room temperature, although the fall in stress at the yield point is rather small. When tested at -77°C , the yield point phenomena is quite marked. When the testing temperature is lowered still further, to -190°C , the crystal deforms by twinning instead of slip. On the other hand, if the yield point phenomenon at room temperature is removed by decarburization or a small amount of plastic deformation, then the crystal deforms entirely by slip at -190°C . These results are interpreted on the basis of a very steep dependence of the upper yield stress on temperature. As the temperature is lowered, the upper yield stress increases rapidly until, at very low temperatures, it becomes higher than the critical stress required for twinning, at which point the specimen deforms by twinning without any slip deformation. In crystals not exhibiting a room temperature yield point, however, it is assumed that the elastic limit for slip varies only moderately with temperature and remains lower than the critical twinning stress even at -190°C . A preliminary account of these experiments appeared in *Nature* 167, 943 (June 9, 1951).

According to Cottrell's theory of the yield phenomenon, a body-centered cubic metal is more likely to exhibit a yield point than a face-centered cubic one; in the former, the interstitial sites become non-spherical when occupied by solute atoms and are more likely to anchor dislocations than the spherical interstitial sites in FCC metals. Recent experiments, however, indicate that alpha brass crystals containing dissolved nitrogen exhibit a yield point. It is possible that this behavior is due to the presence of the zinc atoms which have destroyed the sphericity of the

interstitial sites; this idea will be checked by experiments in which the zinc content is progressively decreased until pure copper is tested.

ISOTOPES TECHNIQUES CONFERENCE -(BIOSCIENCES)

Several papers of interest to bioscientists are discussed below. These papers were presented at the Isotopes Techniques Conference described elsewhere in this issue.

Thyroid Functions at Low Oxygen Pressure

Thyroid function in rats was tested by the use of ^{131}I . Clinical and experimental observations by Prof. F. Verzan (Basel) and his colleagues indicated that the function of the thyroid is probably influenced by atmospheric oxygen pressure. 0.01 to 0.05 mC was injected i.p. into rats and the concentration of ^{131}I measured in the thyroid of the living animal. In normal animals all ^{131}I is concentrated in the gland in 16-24 hours.

When rats were placed under low oxygen pressure for 2 days the uptake of ^{131}I was distinctly diminished. Little or no influence on uptake was shown by a pressure of 400 mm/Hg, but a distinctly lowered uptake was found at 330, 280 and maximally at 250 mm/Hg.

If rats under such low oxygen pressure are cooled their rectal temperature may fall to about 15°C . They can then be kept alive in a state of unconsciousness and without reflexes for about a day. In this state the thyroid is completely inactive and no ^{131}I is concentrated. If, however, the animal's body temperature rises above 30°C , the thyroid again becomes active and the ^{131}I distributed over the body is concentrated in the thyroid within a few hours.

At very low oxygen pressures the body temperature of animals and men falls, and this is probably the result of the inactivity of the thyroid through lack of oxygen. How far this disturbance is of central nervous or pituitary origin is being studied at present.

The adrenal cortex becomes hypertrophic at low atmospheric pressure. It was shown that the treatment of

normal rats with adrenal cortical extracts, desoxycorticosterone and cortisone, decreases thyroid activity both in the uptake and the release of I^{131} .

The thyroid inactivity at low oxygen pressure and the adrenal cortical hyperactivity are closely related. Their influence on metabolism must be considerable and might represent an adaptation to decrease oxygen uptake.

Methionine and Isotopic Therapy in Malignancies

Dr. J. W. Otte of Central Hospital, Madrid, attempted to improve the therapeutic results in the treatment of melanomata with multiple metastases and of bone metastases in breast carcinoma by simultaneous administration of amino acids with radioactive phosphorus. The basis for amino acid therapy rests in the possible increase in uptake of radioactive material in the tumorous secondaries or increasing the general tolerance of the patient to radiation.

Methionine was found to give the best protection to patients treated with P^{32} , although the exact mechanism of this action is unknown. There seems to be no real inhibition of absorption. Methionine did not increase the urinary excretion of P^{32} . Cysteine and hydroquinones gave probable results which may justify further research.

Movement of I^{131} Labelled Protein in Nerve Tissue

A novel method for investigating the possible centripetal movement of toxin along the nerve trunks was used by Prof. G. Payling Wright, Dr. E. A. Wright, and Dr. R. S. Morgan of Guy's Hospital Medical School, London, when studying the pathogenesis of tetanus. To prevent any possible interference with the action of the toxin by the I^{131} , a labelled molecule of low activity was used rather than labelling the toxin itself. The tetanus toxin and radioiodinated rabbit serum protein were mixed and inoculated into the sciatic nerve of rabbits. A volume of 0.04 ml was used. The volume of the sciatic nerve and cord was considered to be approximately 40 ml. Thus the inoculum-tissue ratio was about 1:1000. Speed of travel of the inoculum was not studied. The drive in the peripheral trunks

is thought to be due to muscular contraction but no satisfactory explanation could be made for the movement of the inoculum in the cord. The path of travel was between the nerve fibers in the endoneurium. A localized 2-3 cm length of nerve destruction resulted. Generalized muscular effects developed in 16-30 hours. In controls with the cord transected no generalized tetanus developed although there was some localized tetanus.

PRODUCTION OF POLYPLOIDY IN MAMMALS

M. Fischberg and R. A. Beatty of the Department of Animal Genetics, University of Edinburgh, have developed a method for the production of polyploidy in mice through heat treatment of the ova.

Mice are bred and at the time of the expected second polar body formation are anesthetized. Through small incisions in the back, the ovaries, the fallopian tubes, and the upper end of the uterus are withdrawn into a small plastic water bath which is fitted to the animal. These organs are then exposed to circulating saline at a temperature of 45°C for five minutes, after which they are returned to the body cavity. The mice are killed 3½ days later and the segmenting ova washed out of the fallopian tubes.

By this method polyploidy is produced in 20 percent of the eggs, a few of which are tetraploid. The chromosomes are counted in "squash preparations" where they are clearly visible, and excellent photomicrographs can be taken. Tetraploid embryos are considerably larger than those with smaller chromosome number. The embryos appear to be viable, and it is planned to allow some to become older.

This study is the second to report the production of polyploid mammals, the first being a report of Swedish investigators on the production of triploid mammals by the use of colchicine.

DEVELOPMENT OF VARIOUS SOMATIC EXPRESSIONS OF A SINGLE GENE

The genetic character "crinkly" in mice is carried by a single gene which expresses itself in the following characteristics: (1) crinkly hair, (2) a corkscrew tail, (3) small palpebral fissure, (4) absence of "meibomian" glands, and (5) corneal opacity in the adults.

Dr. D. S. Falconer of the University of Edinburgh, Department of Animal Genetics, has studied the development of these characteristics. He finds that in the embryo the only abnormality visible is a deficiency in the development of certain follicles. In the normal mouse three types of hair are formed at three different periods in development. In mice with the "crinkly" gene, only one of these hair types develops, which is the normal kinky hair of the mouse. Therefore, this gene prevents the development of two types of hair normally present. This is considered the primary expression of the gene and is the direct cause of the peculiar coat pattern.

Reduction in the number of hair follicles makes the mouse's tail even more naked than normal, since the only hairs on a mouse's tail are of the two types absent in this genetic strain. The failure of hair follicles to develop is thought to cause a reduction in the amount of tail skin so that, it is suggested, the tail vertebrae are deformed, buckle, and thereby cause kinking. Eyelashes also do not form and there are no associated meibomian glands. The absence of lash follicles and glands in the lid is thought to cause a shortening of the palpebral fissure in the same manner as the length of the tail skin was affected.

Lastly, the opaque cornea, it is suggested, results from the absence of meibomian gland secretion, which Falconer believes is necessary for corneal transparency.

FORMATION OF HYDROCHLORIC ACID IN THE STOMACH

It is well known that there is an electric potential difference across many living membranes, which is maintained by metabolic processes. For example, in the case of frog skin this electric potential difference is largely maintained by the active transfer of sodium ions inward.

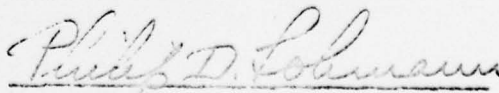
Dr. A. Hogben, under the direction of Prof. Hans Ussing at the Zoofysiologiske Laboratorium, Copenhagen, has been studying the electric potential across the gastric mucosa of the frog. These studies have been carried out by the use of isotopic tracers. It has been found that the electric current generated is derived solely from the active transfer of chloride ions from the vascular side to the secretion side of the mucosa, while there is simultaneously an active transport of bicarbonate ions in the opposite direction. The hydrochloric acid of the stomach, therefore, seems to arise as a result of a forced exchange of bicarbonate against chloride ions. According to this concept, there would be no need for a mechanism of hydrogen ion secretion or transport to explain gastric acidity.

TECHNICAL REPORTS OF ONRL

The following technical reports have been issued by this office during the period 1 August 1951 to 12 September 1951:

- ONRL-57-51, "The Dynamics of Ionized Media", by S. C. Lowell and S. F. Singer
- ONRL-64-51, "Research in Kinetics and Thermodynamics at the Nuffield Research Group in Extractive Metallurgy", by B. D. Cullity and A. J. Shaler
- ONRL-65-51, "The British Interplanetary Society", by S. F. Singer
- ONRL-66-51, "Low Temperature Technology in the Department of Chemical Engineering, Imperial College, London", by P. M. Marcus
- ONRL-69-51, "Cosmic Ray Research at the Ecole Polytechnique, Paris", by S. F. Singer
- ONRL-70-51, "Colloquium on the Chemotherapy of Tuberculosis, Dublin, Eire, July 10-13, 1951," by Captain J. P. Wood (MC) USN
- ONRL-71-51, "Photoelectric Determination of Track Densities in Nuclear Emulsions", by S. F. Singer

Prepared by the Scientific Staff
Submitted by Dr. Samuel R. Aspinall
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